

## CLAIMS

[1] A rotation and extension/retraction link mechanism with a first link therein and a second link therein coupled through a rotation and extension/retraction joint mechanism, said first link having a first virtual center line and said second link having a second virtual center line, wherein

said rotation and extension/retraction joint mechanism is constructed so that it couples said first link and said second link in such a manner that when the second virtual center line rotates relative to the first virtual center line from a state where the first virtual center line entirely overlaps with the second virtual center line, while crossing the first virtual center line, an intersection between the first virtual center line and the second virtual center line moves on the first virtual center line by a predetermined distance corresponding to an angle of the rotation.

[2] The rotation and extension/retraction link mechanism according to claim 1, wherein

said first link includes first and second opposing wall portions facing each other at a predetermined spacing;

said second link includes a first opposed wall portion facing said first opposing wall portion and a second opposed wall portion facing said second opposing wall

portion; and

said rotation and extension/retraction joint mechanism includes:

a first rack gear provided at said first opposed wall portion and extending along the second virtual center line;

a first sector gear including a plurality of cogs to be engaged with said first rack gear, said first sector gear being slidably supported by said first opposing wall portion so that said first sector gear rolls on said first rack gear and slides along the first virtual center line;

a second rack gear provided at said second opposing wall portion and extending along the first virtual center line; and

a second sector gear including a plurality of cogs to be engaged with said second rack gear, said second sector gear being slidably supported by said second opposed wall portion so that said second sector gear rolls on said second rack gear and slides along the second virtual center line.

[3] The rotation and extension/retraction link mechanism according to claim 2, wherein shapes and sizes of said first rack gear and said first sector gear and a positional relationship therebetween, and shapes and sizes of said second rack gear and said second sector gear and a positional relationship therebetween are determined so that, as viewed in projection perpendicular to a virtual plane in which the first virtual center line and said second

virtual line are both present, a first relative rotation amount of said first sector gear relative to said first rack gear becomes equal to a second relative rotation amount of said second sector gear relative to said second rack gear, a first relative rotation direction of said first sector gear relative to said first rack gear becomes opposite to a second relative rotation direction of said second sector gear relative to said second rack gear, a first sliding amount of said first sector gear along the first virtual center line becomes equal to a second sliding amount of said second sector gear along the second virtual center line, and a first sliding direction of said first sector gear along the first virtual center line becomes relatively opposite to a second sliding direction of said second sector gear along the second virtual center line.

[4] The rotation and extension/retraction link mechanism according to claim 2, wherein shapes and sizes of said first rack gear and said first sector gear and a positional relationship therebetween, and shapes and sizes of said second rack gear and said second sector gear and a positional relationship therebetween are determined so that a minimum distance between a center of rotation of the second virtual center line and the first virtual center line and a minimum distance between said center of rotation and the second virtual center line always become substantially constant, said center of rotation being

defined in said virtual plane when the second virtual center line relatively rotates with respect to the first virtual center line.

[5] The rotation and extension/retraction link mechanism according to claim 2, further comprising:

a driving force applying mechanism which generates at least one driving force among a driving force that causes said first sector gear to roll relative to said first rack gear, a driving force that causes said first sector gear to linearly move along the first virtual center line, a driving force that causes said second sector gear to roll relative to said second rack gear, and a driving force that causes said second sector gear to linearly move along the second virtual center line.

[6] The rotation and extension/retraction link mechanism according to claim 5, wherein said driving force applying mechanism comprises:

a common shaft with an axis line thereof located at an intersection between the first virtual center line and the second virtual center line, said common shaft vertically extending with respect to said virtual plane and also rotatably passing through said first sector gear and said second sector gear;

a pulley supported by said common shaft;

a driving rope that passes over said pulley and extends

both along the first virtual center line and the second virtual center line;

a rope winding device that winds up said driving rope;  
and

a rope tension generating mechanism that adjustably generates tension of said driving rope;

a leading end of said driving rope pulled out from said rope winding device is fixed to one of said first link and said second link; and

said driving rope is wound up by said rope winding device and the tension is given by said rope tension output generating mechanism, thereby generating both the driving force that causes said first sector gear to linearly move along the first virtual center line and the driving force that causes said second sector gear to linearly move along the second virtual center line.

[7] The rotation and extension/retraction link mechanism according to claim 6, wherein a return mechanism that always generates a force for relatively rotating the first virtual center line and the second virtual center line is further comprised between said first link and said second link.

[8] The rotation and extension/retraction link mechanism according to claim 1, wherein said first and second opposed wall portions of said second link are located between said

first and second opposing wall portions, respectively.

[9] The rotation and extension/retraction link mechanism according to claim 1, wherein said first opposed wall portion of said second link and said second opposed wall portion of said second link are arranged at a predetermined spacing; and

said first link and said second link are combined to alternate with each other in such a manner that said first opposing wall portion, said first opposed wall portion, said second opposed wall portion, and said second opposing wall portion are arranged in order.

[10] The rotation and extension/retraction link mechanism according to claim 1, wherein said first opposed wall portion of said second link and said second opposed wall portion of said second link are arranged at a predetermined spacing; and

said first link and said second link are combined to alternate with each other in such a manner that said first opposing wall portion, said first opposed wall portion, said second opposing wall portion, and said second opposed wall portion are arranged in order.

[11] The rotation and extension/retraction link mechanism according to claim 1, wherein sliding projecting portions are provided at one of said first sector gear and

said first opposing wall portion and one of said second sector gear and said second opposed wall portion, respectively, and sliding recess portions to be slidably fit into said sliding projecting portions are provided at the other of said first sector gear and said first opposing wall portion and the other of said second sector gear and said second opposed wall portion, respectively.

[12] The rotation and extension/retraction link mechanism according to claim 2, wherein at least one of said first and second opposing wall portions of said first link and said first and second opposed wall portions of said second link are constructed so that a length thereof in a direction of the corresponding virtual center line can be mechanically adjusted.

[13] The rotation and extension/retraction link mechanism according to claim 1, wherein said rotation and extension/retraction joint mechanism comprises:

- a first rack gear provided at said first opposed wall portion and extending along the second virtual center line;

- a first sector gear slidably supported by said first opposing wall portion so that said first sector gear slides along the first virtual center line;

- a first reversing gear located between said first rack gear and said first sector gear, said first reversing gear being engaged with both of said first rack gear and said

first sector, for rotation;

a second rack gear provided at said second opposing wall portion and extending along the first virtual center line;

a second sector gear slidably supported by said second opposed wall portion so that said second sector gear slides along the second virtual center line; and

a second reversing gear located between said second rack gear and said second sector gear, said second reversing gear being engaged with both of said second rack gear and said second sector gear, for rotation.

[14] The rotation and extension/retraction link mechanism according to claim 13, wherein shapes and sizes of said first rack gear, said first sector gear, and said first reversing gear and a positional relationship thereamong, and shapes and sizes of said second rack gear, said second sector gear, and said second reversing gear and a positional relationship thereamong are determined so that, as viewed in projection perpendicular to a virtual plane in which the first virtual center line and said second virtual line are both present, a first relative rotation amount of said first sector gear relative to said first rack gear becomes equal to a second relative rotation amount of said second sector gear relative to a second rack gear, a first relative rotation direction of said first sector gear relative to said first rack gear becomes



opposite to said second relative rotation direction of said second sector gear relative to said second rack gear, a first sliding amount of said first sector gear along the first virtual center line becomes equal to a second sliding amount of said second sector gear along the second virtual center line, and a first sliding direction of said first sector gear along the first virtual center line becomes relatively opposite to a second sliding direction of said second sector gear along the second virtual center line.

[15] The rotation and extension/retraction link mechanism according to claim 14, further comprising:

a driving force applying mechanism which generates at least one driving force among a driving force that causes said first sector gear to roll relative to said first rack gear, a driving force that causes said first sector gear to linearly move along the first virtual center line, a driving force that causes said second sector gear to roll relative to said second rack gear, and a driving force that causes said second sector gear to linearly move along the second virtual center line.

[16] A serial multi-joint mechanism comprising:

a plurality of rotation and extension/retraction link mechanisms according to claim 6 or 7 connected in series.

[17] A serial multi-joint mechanism comprising:

a plurality of rotation and extension/retraction link mechanisms according to claim 6 or 7 connected in series;

said driving rope added for driving said rotation and extension/retraction joint mechanisms being pulled around one or more pulleys within one or more of said rotation and extension/retraction joint mechanisms being present between said rope winding device which winds up or unwinds said driving rope and said rope tension output generating mechanism, and one of the rotation and extension/retraction joint mechanisms.